## Authors' Reply to Wang

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LETTER TO THE EDITOR

# Authors' Reply to Wang: "On Magnetic Resonance Imaging of Intervertebral Disc Ageing"

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Dear Editor,

Thank you for forwarding the letter from Dr. Wang regarding our recent publication [1] in *Sports Medicine*. It is nice to know that the article is generating interest.

While we agree with most of the comments by Dr. Wang, the topic of the letter "On Magnetic Resonance Imaging of Intervertebral Disc Ageing" is peripheral to the review we wrote on exercise and the intervertebral disc (IVD). For example, while we know clinically that some people can have IVD degeneration in their 20s, this is not directly relevant to the point we were trying to get across: namely that perhaps there is a "critical period" in human development for the IVD in terms of when loading and exercise can have the greatest impact on lifetime IVD properties. If there is a "critical period" in ageing for the IVD, such as is considered [2] to be the case for bone tissue, then the exact age span still needs to be narrowed down.

Furthermore, it is known [3] that vertebral body bone properties are related to IVD properties. In drafting the review, owing to the limited data in the literature on this particular point, we did not consider this issue to be currently of high priority to the topic of IVD and exercise. In another review [4] on the topic of IVD herniations in astronauts, some of my colleagues in the team suggested vertebral body bone loss during spaceflight as a potential explanation for increased IVD hydration after spaceflight and also for persistent changes in the IVD after prolonged bed rest [5]. In that particular area, it is therefore very relevant to consider vertebral bone properties. Vertebral body bone material properties (not to mention other factors such as bone marrow fat and end-plate properties, amongst other issues) will have an impact on forces transmitted to the IVD. However, owing to the paucity of data in the literature, it is currently too speculative to discuss how this might influence exercise protocols for training the IVD.

Dr. Wang mentions other radiological grading schemes. We aimed to communicate magnetic resonance imaging approaches for quantifying the IVD in studies of the effect of exercise on the IVD. Our comments on grading schemes—as they apply to quantification of the IVD for studies of the effect of exercise on the IVD—apply to all grading schemes. Just the same as the standard Pfirrmann grading scheme, an eight-level modified Pfirrmann grading scheme, or a scheme including the end-plate, will be of similar limited sensitivity for use in a small sample size exercise (intervention) study. If one were to use a grading scheme as the primary outcome measure of an IVD and exercise study, then the sample size would need to be very large. One example is the cross-sectional study by Hangai et al. [6] on athletic populations and IVD degeneration where the authors had approximately 60 subjects in each group. Hence, we advise other researchers to use other approaches in studies of the effect of exercise on the IVD.

Dr. Wang mentions T1rho as a method of interest for measurement of the IVD, after stating that "caution should

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be exercised in interpreting T2". In our view, the results of all measurement approaches need to be interpreted with caution. For example, one of Dr. Wang's own publications [7] showed very similar time courses for T1rho and T2-time of the IVD across the lifespan. Hence, we remain to be convinced as to whether the T1rho approach can be more informative about the IVD than other approaches. Perhaps, with time, T1rho will be consistently established by a number of research groups as having some advantages over T2-time, or perhaps not. We are currently experimenting with approaches such as the Dixon method and the apparent diffusion co-efficient, but do not have sufficient data at this stage to necessarily recommend them above T2-time.

To ensure that readers of this exchange are not confused: in our view, T2-time is currently the best established [8–11] method for assessing the IVD in the static state with the least amount of risks. Discussions about the use of a contrast agent, which can be very useful for specific research questions, such as nutrient supply into the IVD [12, 13], are a larger issue and we refer the reader to other reviews [14, 15] on this point. For investigating the effect of exercise on the IVD, it is necessary to have a reproducible and precise measure. In our team, we have quite good reproducibility of T2-time measures between testing days, with a correlation of 0.982 between testing days and a co-efficient of variation of 1.7 % for lumbar IVD T2-time (unpublished observations by Daniel Belavý, Gabriele Armbrecht, Jochen Zange, Martin Bansmann and Dieter Felsenberg) and can obtain a nice anatomical localisation of T2-time through the volume of the IVD (Fig. 1). For tracking differences between groups in cross-sectional studies and changes within individuals in interventional studies for the IVD, it is important to have a measurement approach with these characteristics. As such, whilst other imaging sequences may prove more useful in the future, and there are other methods such as with contrast agent that have their uses, we currently recommend using T2-time for assessment of regional IVD composition for the interventional exercise study of the IVD.

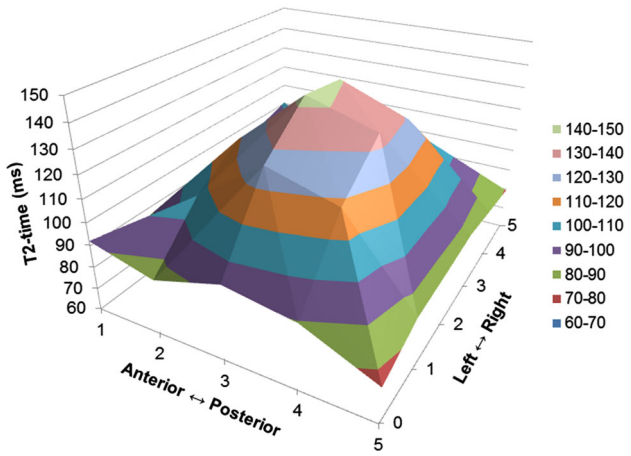


**Fig. 1** Example of T2-time localisation in the lumbar intervertebral discs (IVDs) of 12 men. Data are mean T2-time in subregions (from anterior to posterior) of the IVD in six anatomical slices through the IVD. T2-times are higher in the hydrated nucleus. (Data from Daniel Belavý, Gabriele Armbrecht, Jochen Zange, Martin Bansmann and Dieter Felsenberg; unpublished observations)

### Compliance with Ethical Standards

**Conflict of interest** Daniel Belavý, Pieter-Paul Vergroesen and Jaap van Dieën declare that they have no potential conflicts of interest that are directly relevant to the content of this letter.

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